Example of Human Health Impacts Assessment Associated with Exposure to Previously Contaminated Soil for a Brownfield Site (Example No. 5)

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Introduction

The U.S. Army Engineer Research and Development Center (ERDC) is developing the Army Risk Assessment Modeling System (ARAMS) to provide the Army with the capability to perform human and ecologically based risk/hazard assessments associated with past practice and current activities at military installations. The intent of the system is to provide a platform from which a variety of assessments can be performed. The system is envisioned to help a risk analyst visualize an assessment from source, through multiple environmental media (e.g., groundwater, surface water, air, and land), to sensitive receptors of concern (e.g., humans and ecological endpoints).

ARAMS uses the Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES) developed by the Pacific Northwest National Laboratory (PNNL) for linking disparate objects, such as environmental fate/transport models, databases, spreadsheets, etc. FRAMES is a Windows-based software platform that provides an interactive user interface and, more importantly, specifications to allow a variety of DOS and Windows-based environmental codes to be integrated within a single framework.

This document is intended to serve as a tutorial for helping new users with the application of ARAMS/FRAMES and the components within this system. This example does not include the steps for project planning and the use of associated tools under the "File" menu. These tools help the user plan the risk assessment including development of the conceptual site model and the RAGS Part D Table 1 for human health risk assessment. There are several Help files within ARAMS that explain these tools.

Example Description

This example describes risk assessment for a hypothetical Brownfield site located near a residential area. An adult human is the target receptor for this example, but other receptors could be considered, such as a child. Soil at the Brownfield site is contaminated with cadmium as a result of operation of a battery manufacturing plant. The current reasonable maximum exposure (RME) soil concentration of cadmium based upon field sampling and measurement is 1000 mg/kg. Community stakeholders and public health officials want to know the present health risks for a residential area located adjacent to the Brownfield site. Thus, this is a steady-state (non-time-varying) analysis.

The exposure routes for this scenario are considered to be soil inhalation (from resuspension), soil ingestion, and soil dermal contact. Groundwater and surface water contamination are not concerns for this site. The following FRAMES objects are required for this application: User Defined, Human Exposure Pathways, Human Receptor Intake, and Human Health Impacts. The FRAMES object workspace representing this scenario is shown in Figure 1. The SCF Soil Module within the User Defined Object will be used to define known soil concentrations. MEPAS models will be used for each of the other objects in this example. The Exposure Pathways object is used to declare the exposure pathways. It could also be used to compute time-varying soil concentrations due to leaching, but in this example, the leach rate is specified as 0.0. Thus, the soil concentration is assumed to be constant, i.e., no decay or leaching. The model parameters used for each of the MEPAS models are shown in Table 1. This example also demonstrates use of the report generator for Risk Assessment Guidelines for Superfund (RAGS), Part D tables.

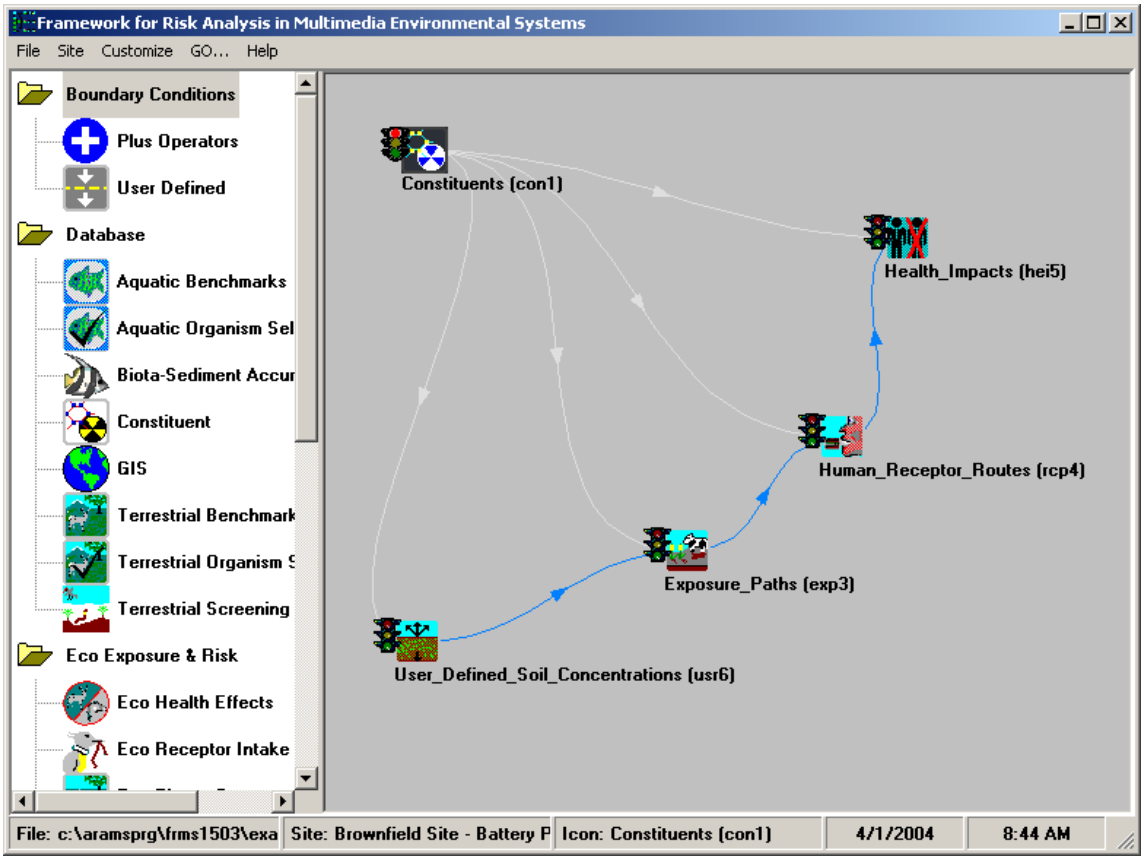

Figure 1. Object workspace for example application

Table 1. Input parameters for example case		
Model/Parameter	Units	Value
Exposure: soil leach rate	cm/yr	0
Exposure: airborne particulate mass loading factor (mass of soil that is suspended in the air above the contaminated soil)	kg/m^3	1×10^{-7}
Receptor: body weight	Kg	70
Receptor: exposure duration	Years	30
Receptor: skin area	cm^2	5800
Receptor: soil adherence factor	mg/cm^2	1.0
Receptor: frequency of soil dermal contact	events/day	1
Receptor: fraction of year that soil dermal contact occurs	unit-less	1
Receptor: soil ingestion rate	g/day	0.1
Receptor: fraction of year that soil ingestion occurs	unit-less	1
Receptor: inhalation rate for resuspended soil	m^3/day	20
Receptor: fraction of year that resuspended soil inhalation occurs	unit-less	1
Constituent database: dermal absorption fraction from soil	unit-less	0.001
Constituent database: gastrointestinal absorption fraction, insoluble	unit-less	0.01
Constituent database: inhalation reference dose	mg/kg/day	2.6×10^{-4}
Constituent database: ingestion reference dose (oral reference dose)	mg/kg/day	0.001
Constituent database: inhalation cancer potency factor (inhalation cancer slope factor)	$(mg/kg/day)^{-1}$	6.1

Input Data

- Double-click on the "ARAMS" icon to open "ARAMS info and Disclaimer" window and then select "Accept" to continue.

- Choose "FRAMES" in the ARAMS toolbar to launch FRAMES. (Note: If this is the first time you have used ARAMS, you will need to configure it for FRAMES by selecting "**File**" " *****Must Configure Path to FRAMES***** " and supplying the path to the "**fui.exe**" file).

- While ARAMS/FRAMES is running, click "File" and choose "New" and a window titled "Global Input Data Open New" will appear (see Figure 2). In the "File Name" box, type the project name (type: "*Sample5*," maximum of eight characters) and click "Open" (see Figure 3). **Do not name the new file "Example5" because it will write over the existing "Example5" file that was distributed with the tutorial.** A window titled "Create New Site" will appear. Type the project site name (type: Brownfield Site) and click "OK" (see Figure 4).

The workspace's color may change. Double-click on the **Constituent** icon so that the icon appears on the upper left corner of the main screen. Repeat this operation to place the following additional icons into the workspace:

"User Defined"
"Exposure Pathways"
"Receptor Intake"
"Health Impacts"

Click on and drag each icon to its respective position on the workspace. Connect the Constituent icon with the User Defined icon by holding down SHIFT, left-clicking on the Constituent icon, dragging - the cursor to the User Defined icon, and releasing the mouse button (Note: To remove this line, repeat the steps used to connect it. To remove an icon from the screen, right-click and a menu will appear with various options. Click "Delete" and the icon will be taken out.).

In the same fashion, connect the following pairs of icons:

Constituent	→	*User Defined (already done)*
Constituent	→	*Exposure Pathways*
Constituent	→	*Receptor Intake*
Constituent	→	*Health Impacts*
User Defined	→	*Exposure Pathways*
Exposure Pathways	→	*Receptor Intake*
Receptor Intake	→	*Health Impacts*

FRAMES should now look something like Figure 1.

CONSTITUENT DATABASE MODULE

Right-click the Constituent icon and choose General Info (see Figure 5). When the General Info screen opens, enter "Constituents" in the "User Label" text box and select "FRAMES Default Chemical Database Selection" in the "Select from applicable models" text box (see Figure 6). Click OK at the bottom of the screen to return to the work area. The status light attached to the Constituent icon will change from black to red. Right-click on the Constituent icon in the main screen and choose "User Input." The Constituent Selection screen will open (see Figure 7). The constituent used in this case is cadmium. Scroll to select the constituent from the constituents list or use the Find option to search for it. Click the "Add >>>" button to add the constituent to the selected constituents list. Click on "Constituent Properties" tab (may have to reselect Cadmium under Constituent Properties); scroll until the Toxicity Parameters and Exposure Factors Categories appear. Change the default values of Dermal Absorption Fraction from Soil, GI Absorption Fraction, Insoluble, Inhalation Reference Dose, Ingestion Reference Dose, and Inhalation Cancer Potency Factor to match those in Table 1. See Figure 8 to ensure that the input values are correct. Click "File" and choose "Save and Exit" to return to the workspace screen. The Constituent icon's status light will change from red to green.

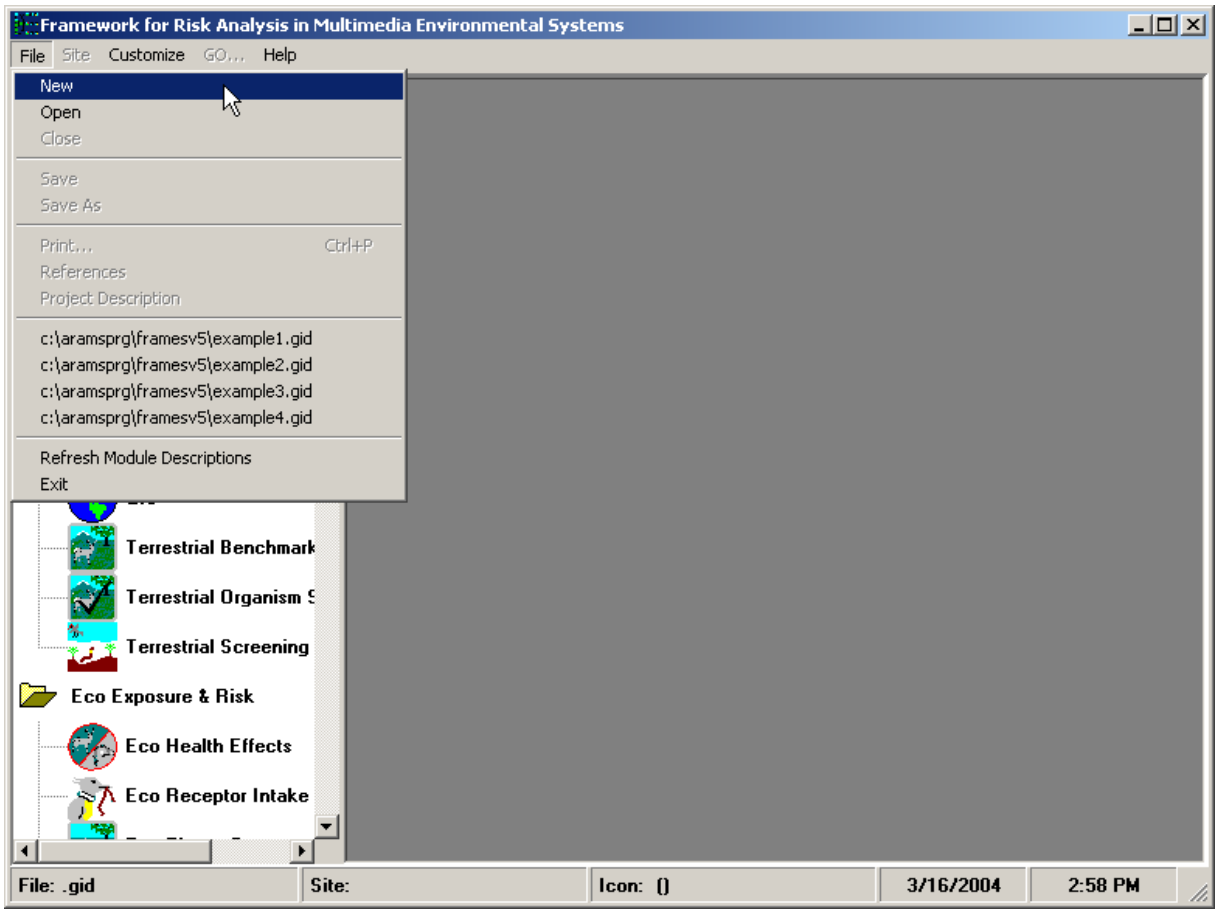

Figure 2. Opening a new file

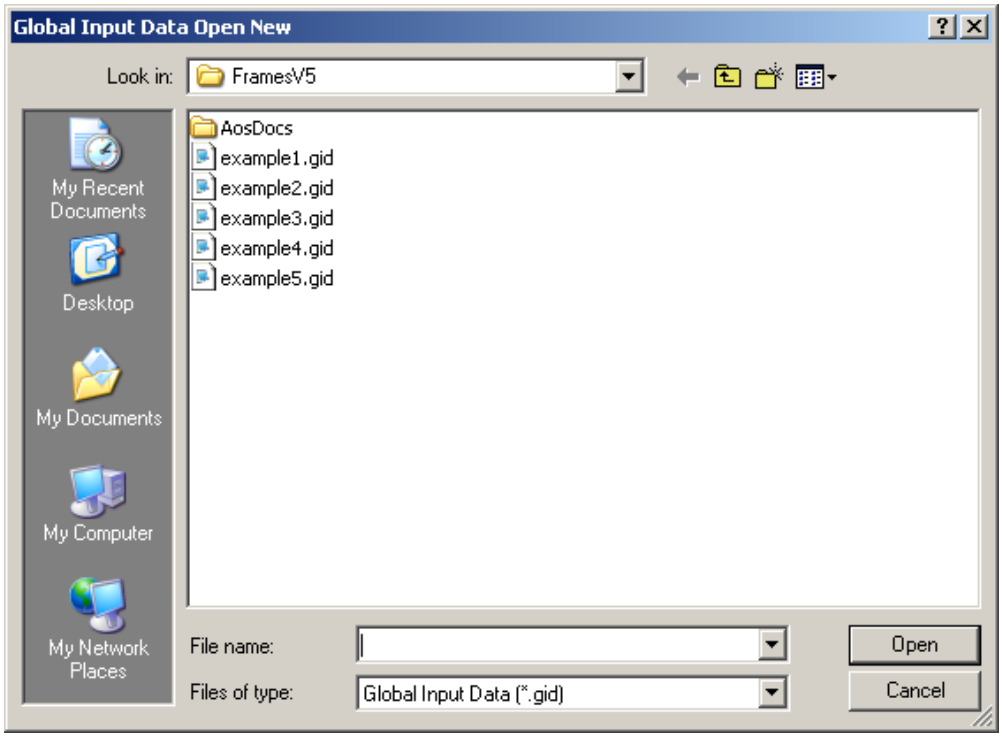

Figure 3. Global Input Data Open New screen (new file window)

Figure 4. Create New Site screen (input “Site name” box)

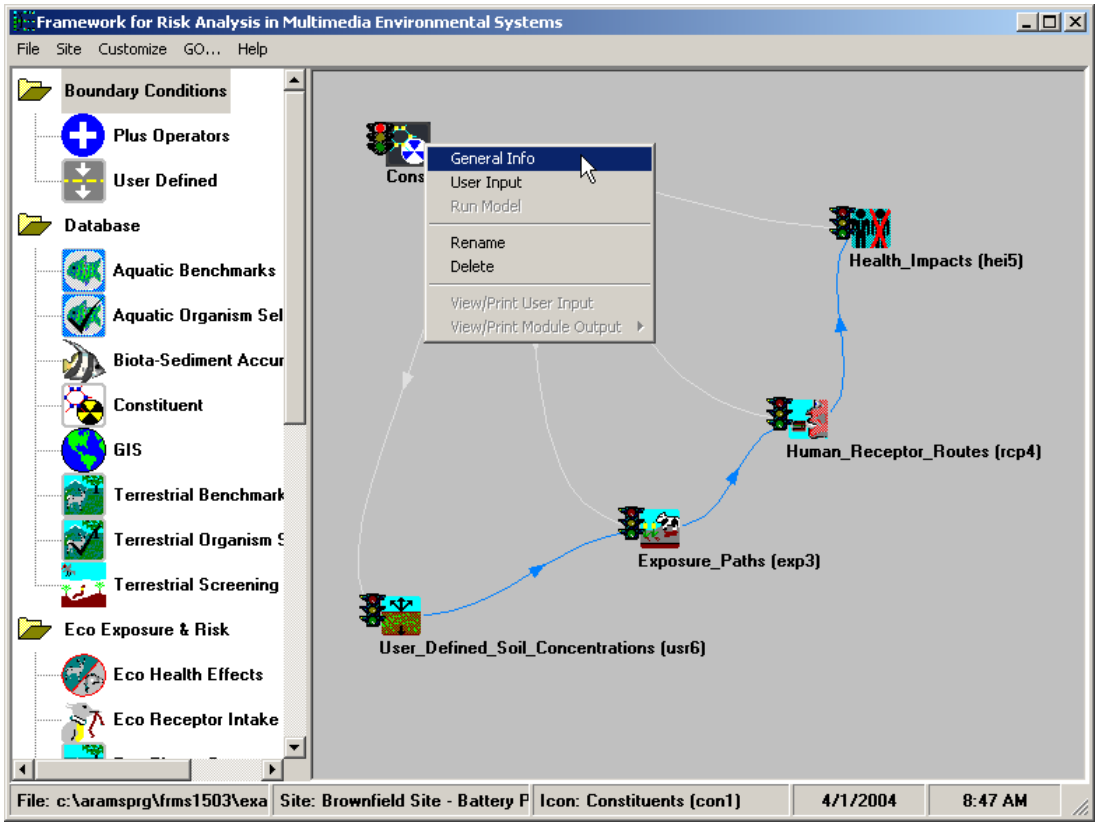

Figure 5. Workspace screen (right-click on the Constituent icon)

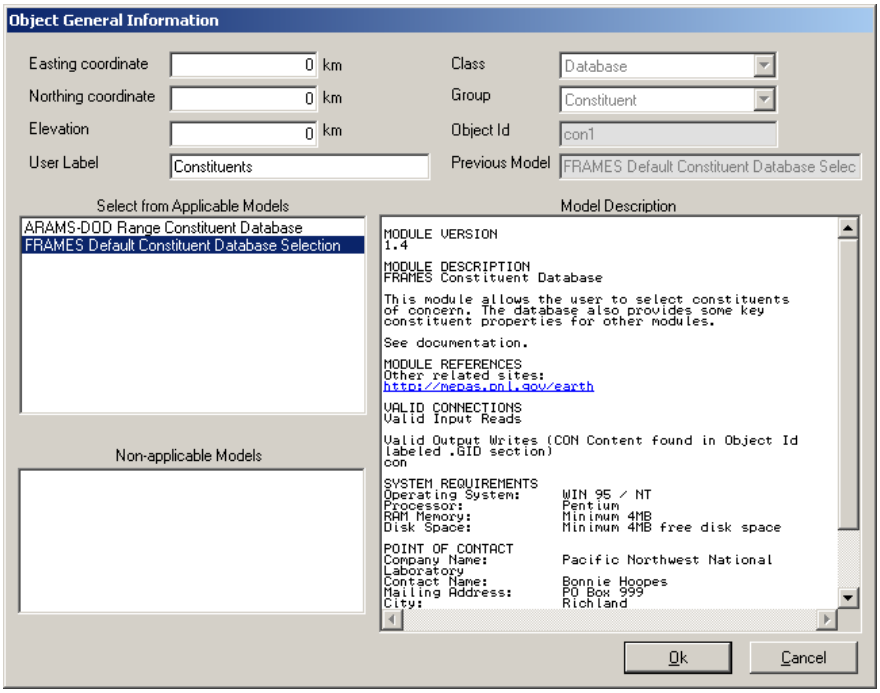

Figure 6. Object General Information screen

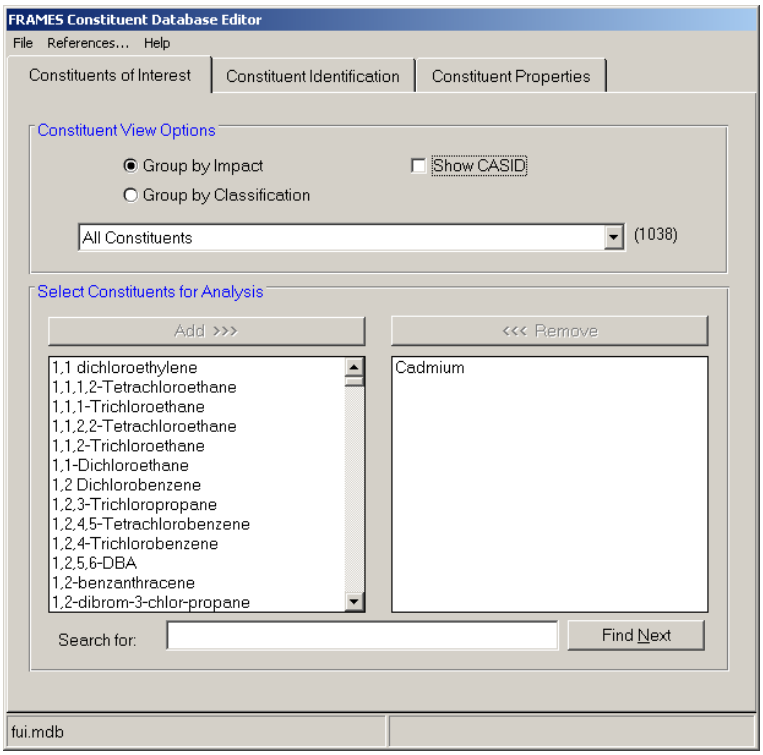

Figure 7. FRAMES Constituent Selection screen ("Constituents of Interest" tab)

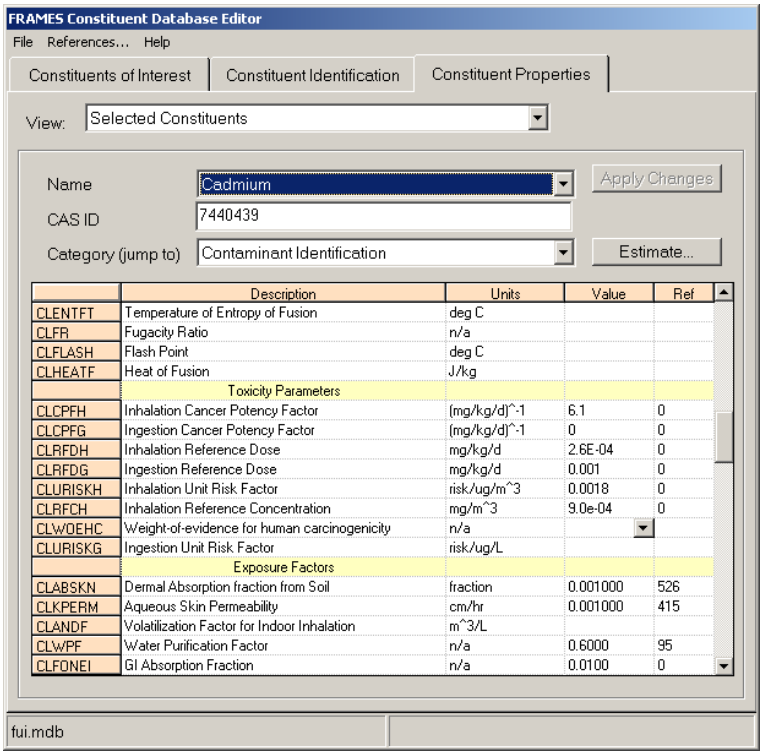

Figure 8. FRAMES Constituent Selection screen ("Constituent Properties" tab)

The following is a listing of all data input required by the remaining modules used in this example. *Names of object icons* are in bold, italics, and underlined headings. *Menu items* (displayed by right-clicking on the icon) are shown below the module in bold and indented to the right of the icon names. *Explanations* of data required by each menu item are indented further to the right. To save information for a scenario, select "File" and then "Save" from the main FRAMES menu.

USER DEFINED

General Info

A window titled "Object General Information" will appear. In the Label text box, type "User Defined Soil Concentrations." In "Select from Applicable Models," choose "SCF Soil Module" and click "Ok." The status light next to the User Defined icon should turn red. The User Defined icon will also change to that of the Source object to reflect that the object is now being used as a source term.

NOTE: The user should first choose each module for each object before entering any data; thus, enter the "General Info" on each remaining module and make a selection before selecting "User Input." After selecting modules, User Input should be performed, and the modules run, starting with the modules at the upper end of the chain and working down the chain.

User Input

A window titled "FRAMES User Defined Module" will appear. Fill it out according to Figure 9. Click "File" and choose "Save and Exit" to return to the work screen. The status light next to the User Defined icon should turn yellow.

Run Model

The model runs in the background. The status light next to the User Defined icon should turn green.

View/Print Module output

A second menu will appear (see Figure 10). Select the "SCF Text View" to view a screen output like Figure 11. Choose "SCF Graphical View" to view a screen output in Excel format (see Figure 12). Note that this is a steady-state problem, i.e., soil concentration does not vary over time, or only the concentration for the present (at time = 0) is of interest, which is the case in many risk assessments.

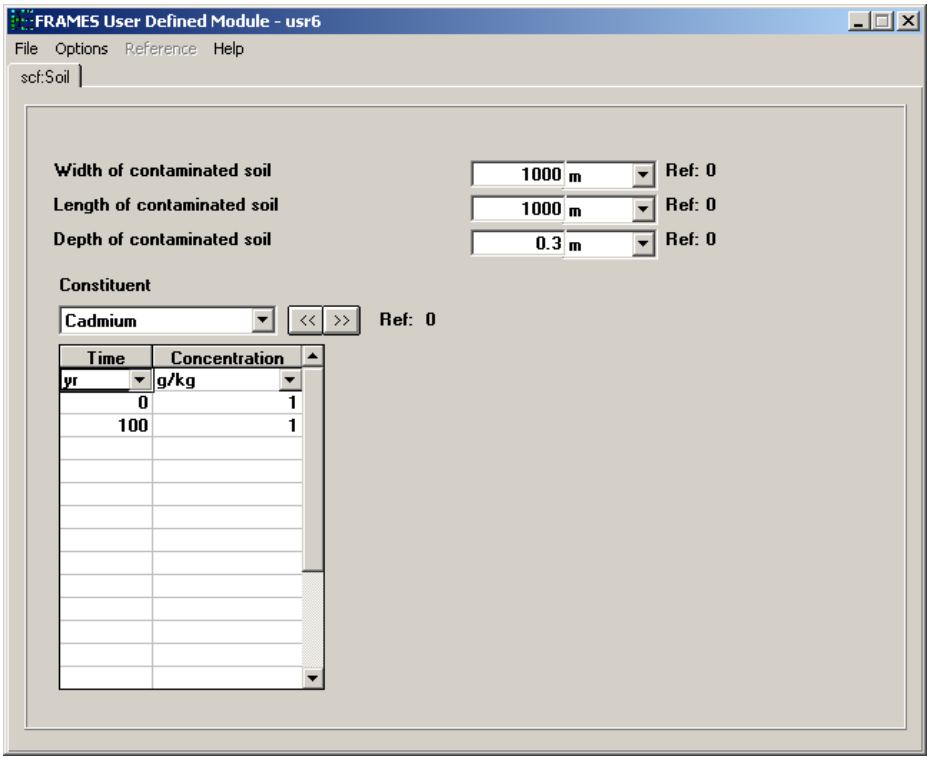

Figure 9. SCF Soil Module Input screen

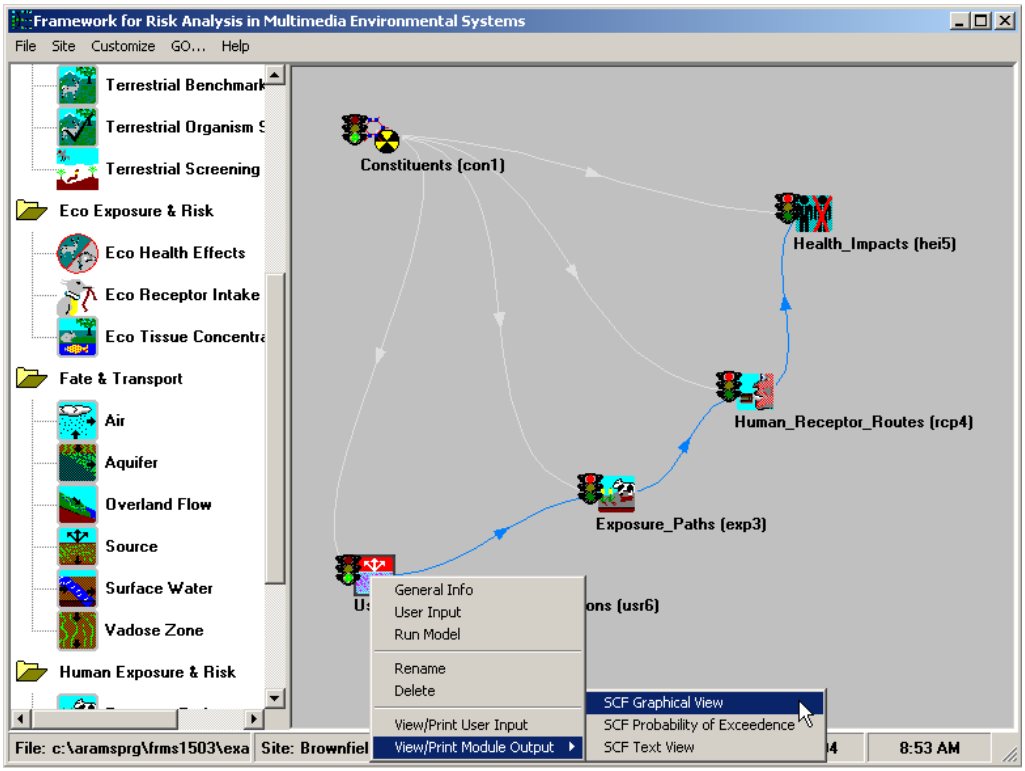

Figure 10. Selecting the output display format

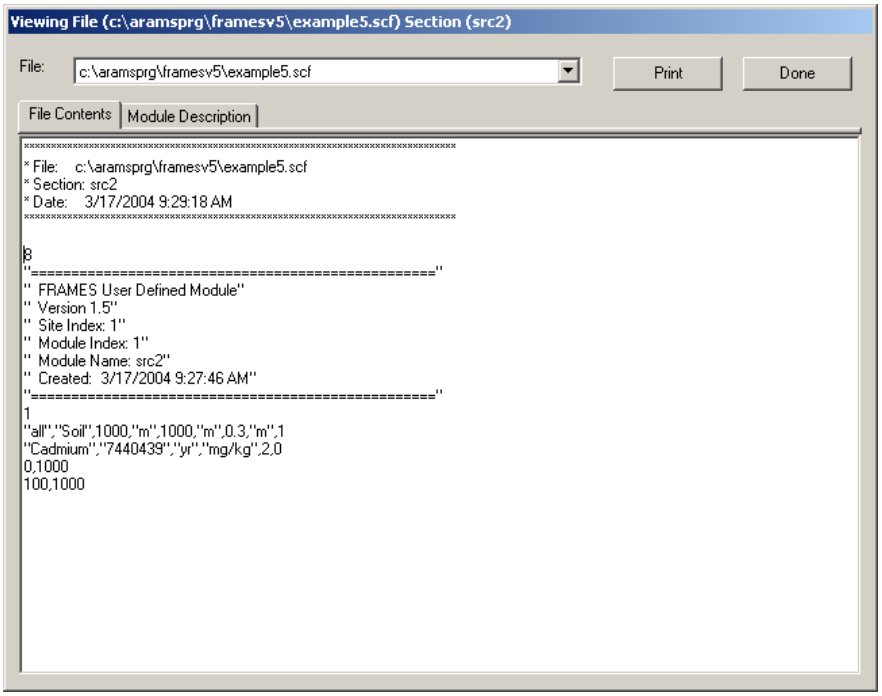

Figure 11. SCF text view

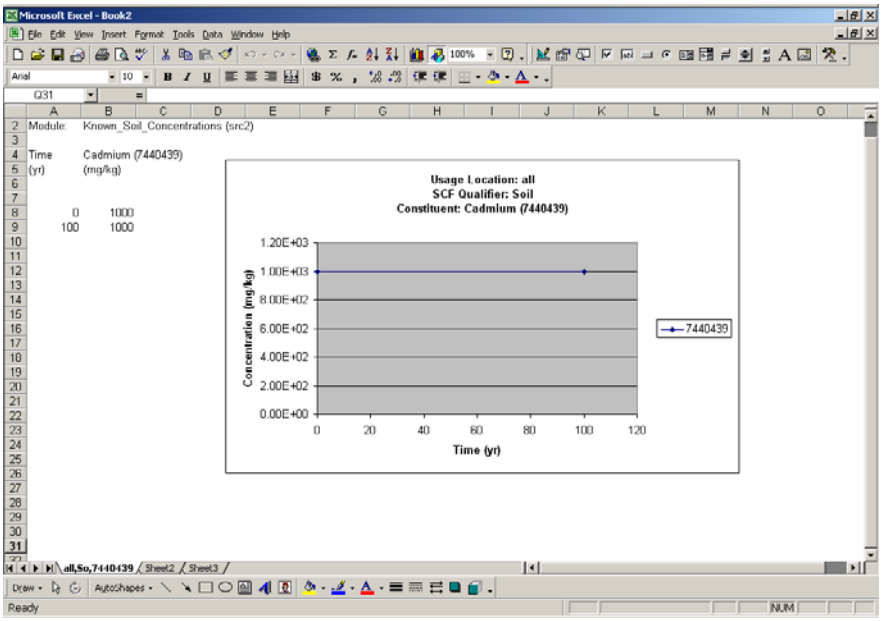

Figure 12. SCF graphical view

EXPOSURE PATHWAYS

General Info

A window titled “Object General Information” will appear. In the Label text box, input “Exposure_Paths.” In “Select from Applicable Models,” choose “MEPAS 4.1 Chronic Exposure Module” and click “Ok.” The status light next to the Exposure Pathway icon should turn red.

User Input

A window titled “MEPAS Chronic Exposure Module" will appear. Click on the “Soil” (see Figure 13) tab and ensure the following:

- Exposure duration – EM-SMED = 30 yr
- Select *Use all time varying soil concentrations from the SCF* in the combo box. Thus, any losses in soil due to leaching and degradation are not considered. **Note:** If the option *Use only the initial soil concentration from the SCF* is used, all but the first value would have been ignored, and the first value is used as an initial condition, and soil concentration can change over time due to leaching and degradation. For this example, we want to hold soil concentrations constant and are only interested in the present time concentration; thus, the “Use All Time Varying Soil Concentration” option is selected. However, the other option can be used to provide constant, steady-state results if the leaching is set to zero, and the degradation half-life in soil is set very high so that there are no losses.

In the “Pathways” tab (under the “Soil” tab) check the following:

Soil-Ingestion, Soil-Inhalation, Soil-Dermal

Click the “Exposure Controls” tab and fill it out according to the data in Figure 14. The maximum time of reporting is set to 50 years. It is noted that if the time of reporting was set to 100 years, the exposure concentrations would decrease after 70 years due to the fact that a sliding forward-looking time average of concentrations is used for the 30-year exposure duration. After year 100, soil concentrations are assumed to be 0.0 due to the soil concentrations that were input in the user defined soil concentrations module; thus, exposure concentrations start to decrease after 70 years.

Click the “Constituent Parameters” tab and fill it out according to the data in Figure 15. Note that the half-life in groundwater may have been required if food ingestion had been selected as a pathway. The groundwater half-life is used for food holdup, after harvesting before consumtion but in a closed system. The value is set very high (1E20 days) so there would be little or no loss for cadmium had there been a food pathway.

Click “Customize” and then click the “Resuspension” tab and fill it out (default values) according to the data in Figure 16.

Then click “File” and choose “Save and Exit” and again click “File” and choose “Save and Exit” to return to the work screen. The Exposure Pathways icon’s status light will change from red to yellow.

Run Model

The model runs in the background in a command prompt window. The status light next to the Exposure icon should turn green.

View/Print Module Output

A second menu will appear. Select the “EPF Text View” to view a screen output like Figure 17. Choose “EPF Graphical View” to view a screen output like Figure 18.

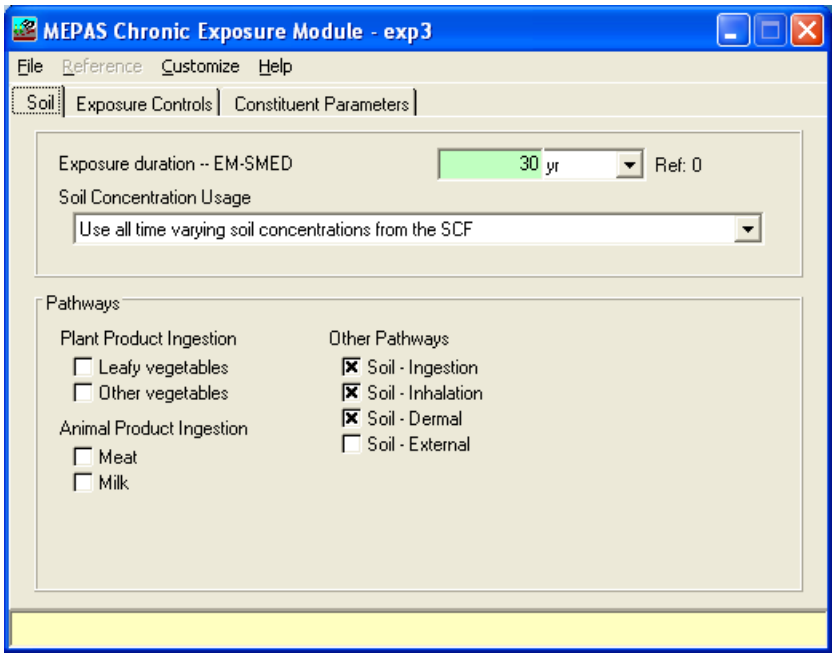

Figure 13. MEPAS Chronic Exposure Module – Soil

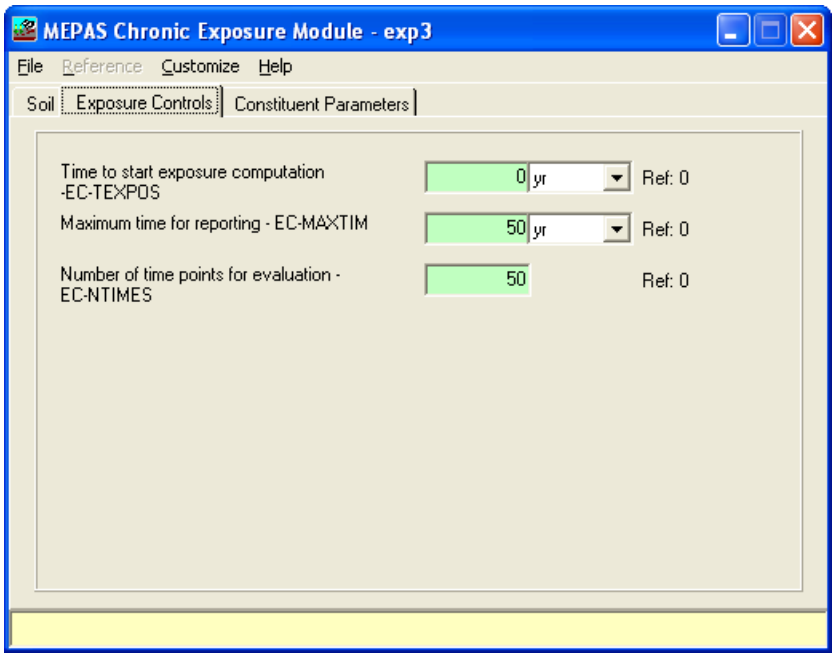

Figure 14. MEPAS Chronic Exposure Module – Exposure Controls

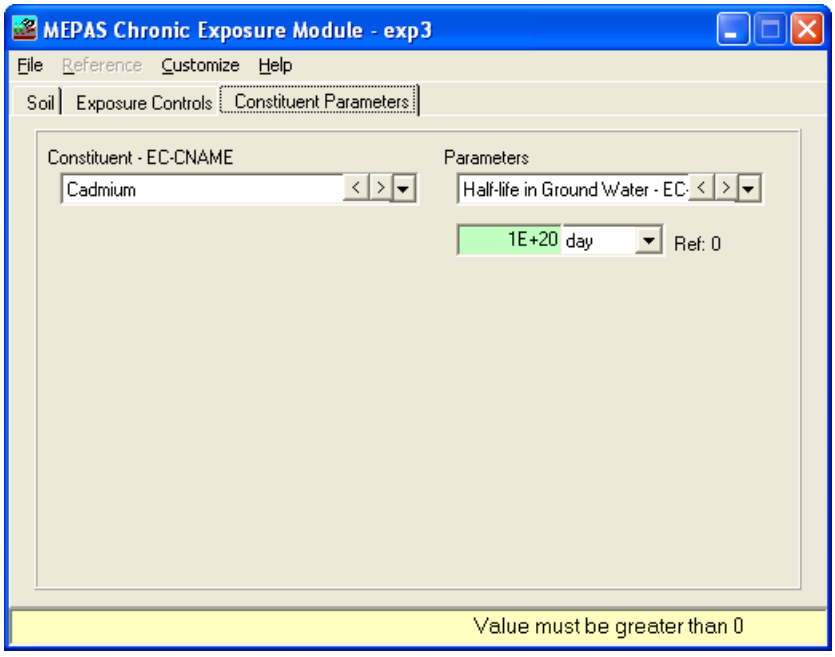

Figure 15. MEPAS Chronic Exposure Module – Constituent Parameters

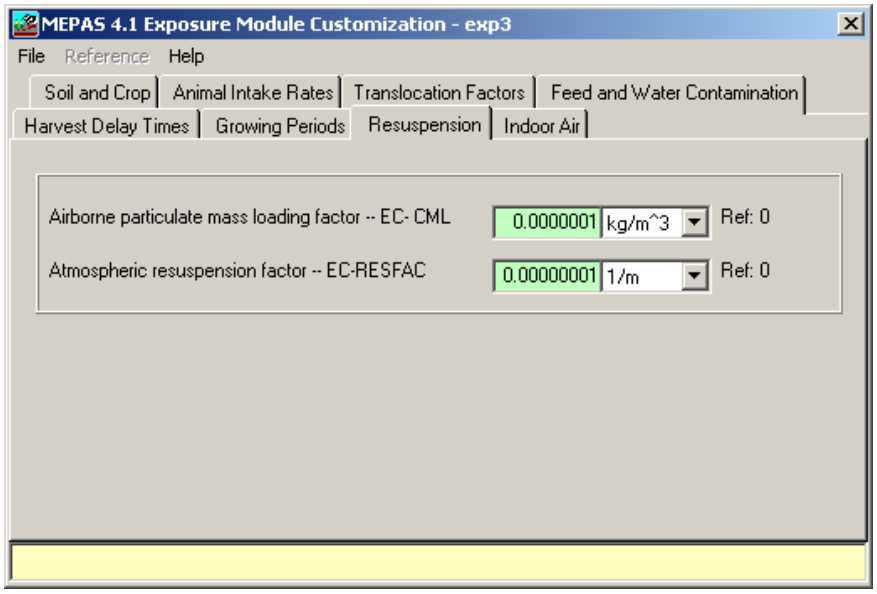

Figure 16. MEPAS Chronic Exposure Module – Customize (resuspension)

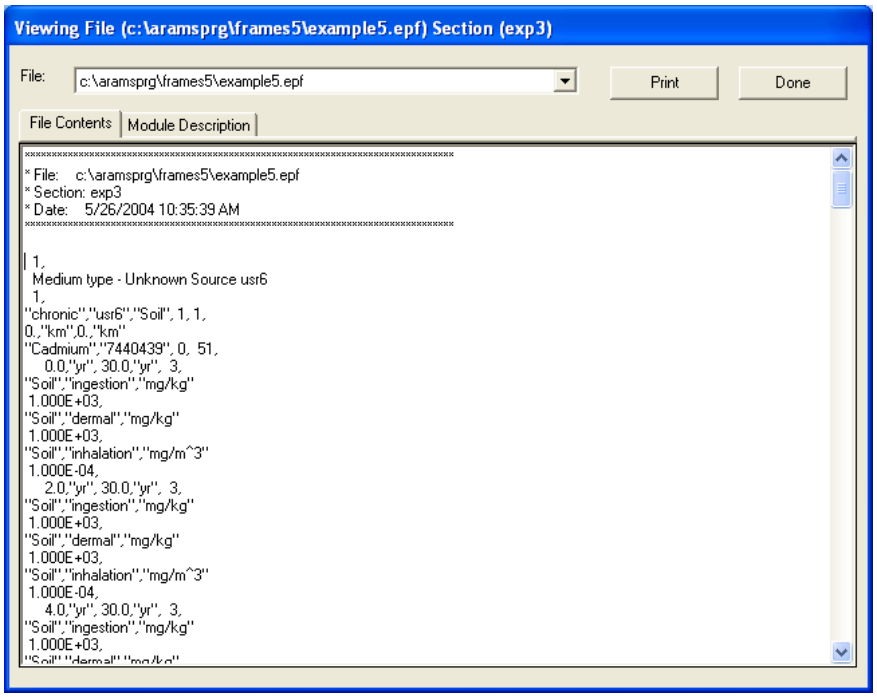

Figure 17. Exposure Pathways Output (text view)

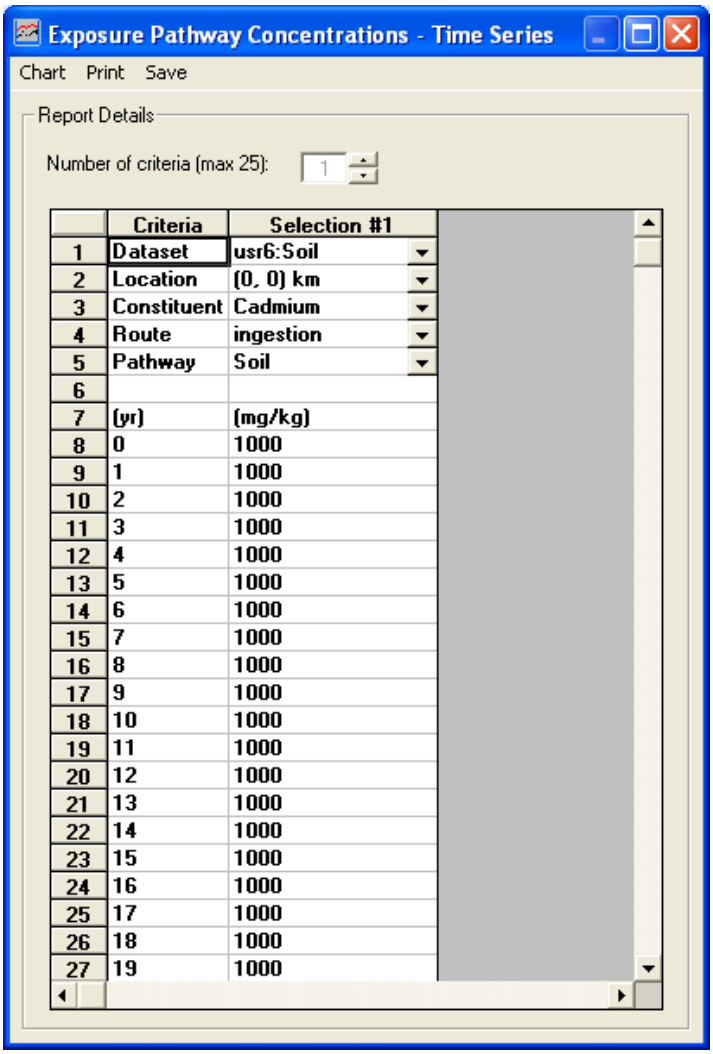

Figure 18. Exposure Pathways Output Screen (graphical view)

RECEPTOR INTAKE

General Info

A window titled “Object General Information” will appear. In the Label text box, input “Human_Receptor_Routes.” In “Select from Applicable Models,” choose “MEPAS 4.1 Intake Module” and click “Ok.” The status light next to the Receptor Intake icon should turn red.

User Input

A window titled “MEPAS Receptor Intake Module" will appear. Fill it out according to Figure 19.

Go to “Customize” and then click the “Soil” tab and fill it out according to Figure 20. Click the “Air Exposure” tab and fill it out according to Figure 21.

Then click “File” and choose “Save and Exit” and again click “File” and choose “Save and Exit” to return to the work screen. The Receptor Intake icon’s status light will change from red to yellow.

Run Model

The model runs in the background in a command prompt window. The status light next to the Receptor icon should turn green.

View/Print Module Output

A second menu will appear. Select the “RIF Text View” to view a screen output like Figure 22. Choose “RIF Graphical View” to view a screen output like Figure 23.

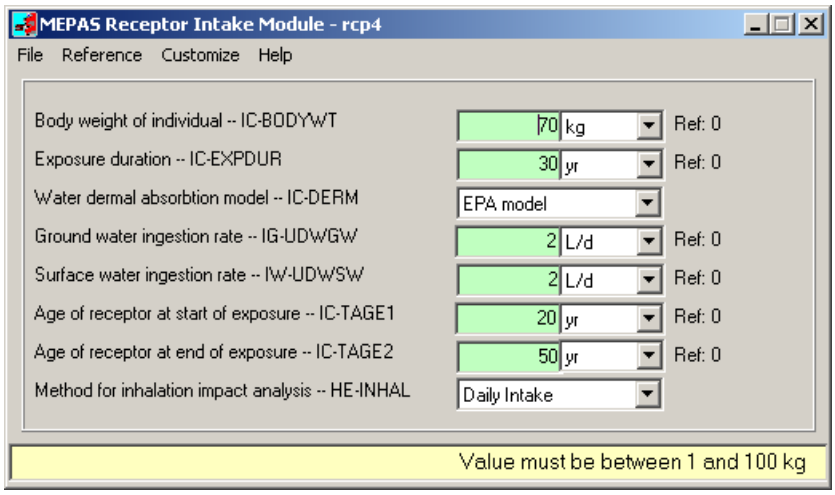

Figure 19. MEPAS Receptor Intake Module screen

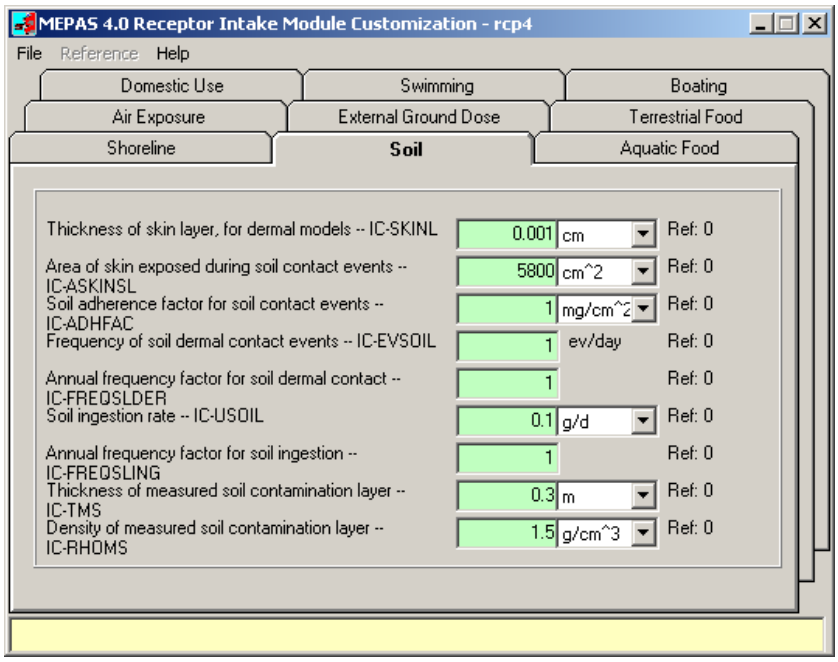

Figure 20. MEPAS Receptor Intake Module screen – Customize (Soil)

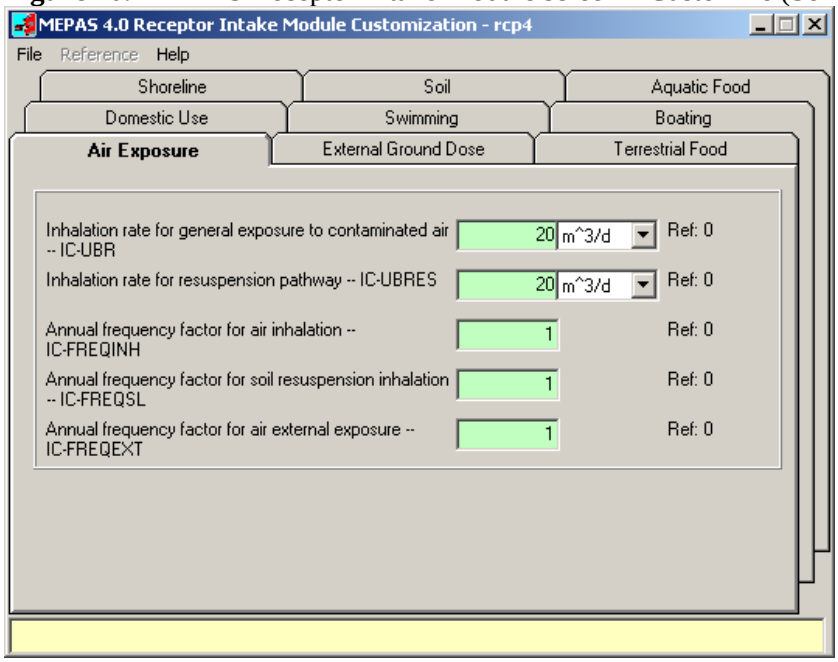

Figure 21. MEPAS Receptor Intake Module screen – Customize (Air Exposure of resuspended soil)

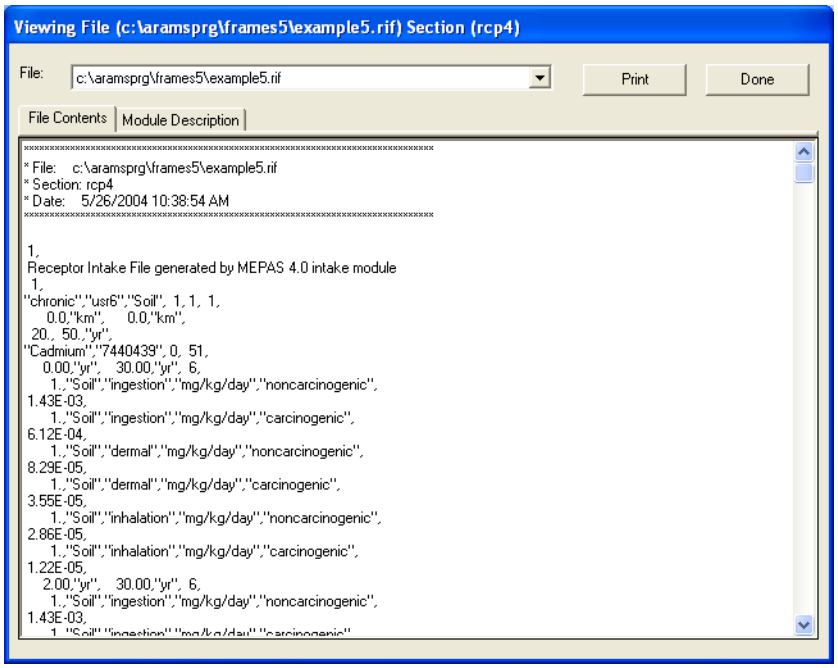

Figure 22. Receptor Intake Output (text view)

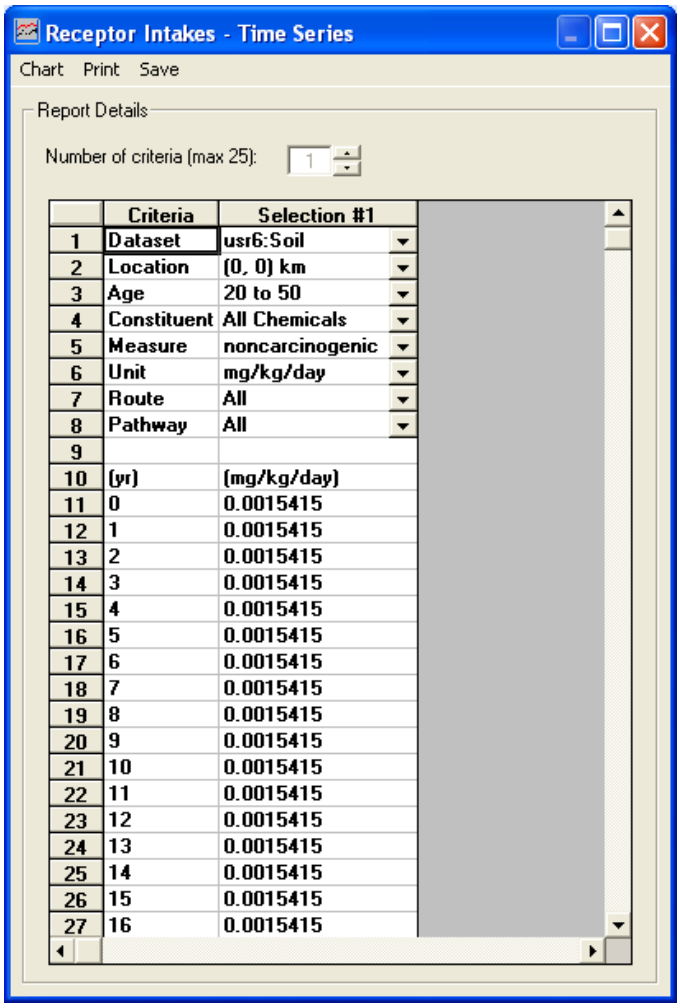

Figure 23. Receptor Intake Output (graphical view)

HEALTH IMPACTS

General Info

A window titled “Object General Information” will appear. In the Label text box, input “Health_Impacts.” In “Select from Applicable Models,” choose “MEPAS 4.1 Human Health Impact Module” and click “Ok.” The status light next to the Health Impacts icon should turn red.

User Input

A window titled “MEPAS Human Health Impacts Module " will appear. Click on the “Chemical” tab and ensure that the following is true in Figure 24.

Go to “File” and choose “Save and Exit” to return to the workspace screen. The Health Impacts icon’s status light will change from red to yellow.

Run Model

The model runs in the background in a command prompt window. The status light next to the Health Impacts icon should turn green.

View/Print Module Output

A second menu will appear (see Figure 25). Select the “*HIF Text View*” to view a screen output like Figure 26. Choose “*HIF Graphical View*” to view a screen output like Figure 27. Click “*RAGS Table Generator”* to generate and populate the Risk Assessment Guildlines for Superfund (RAGS) tables. An interface screen will appear for parameter inputs as shown in Figure 28. The RAGS generator interface allows the user to select from a variety of output to dump into the tables, including results at time = 0.0 (for Central Tendency, CT, or Reasonable Maximum Exposure, RME) or time-varying results. Select “Central Tendency” option and select “All Values” for De Minimus. Then select “Mean” for the Measure. The RAGS tables are generated within Excel using results from the application and are displayed on the screen as shown in Figure 29.

Selecting the “Summary of Risk/Hazard/Dose” output command will result in an output screen like Figure 30.

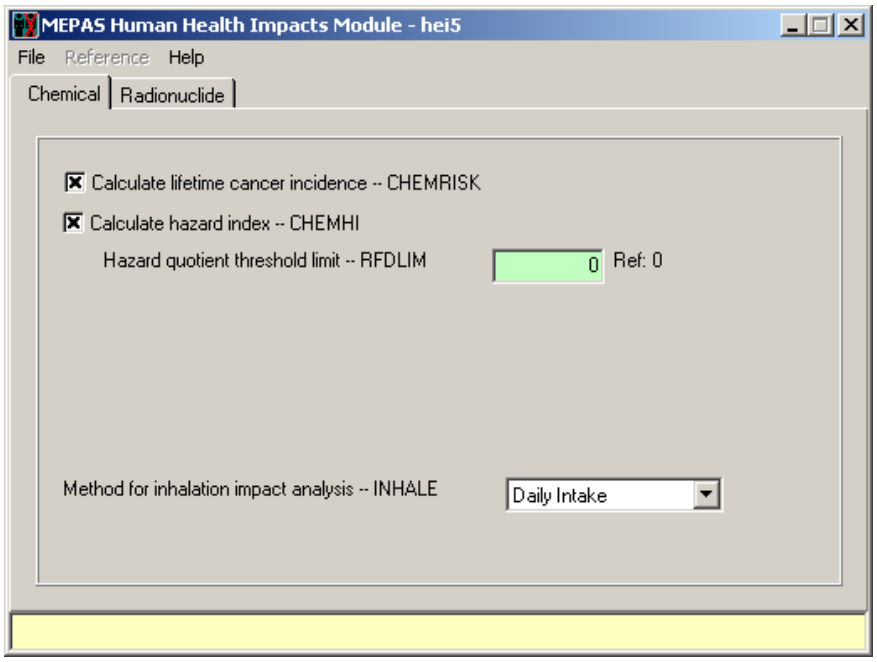

Figure 24. MEPAS Human Health Impacts Module – Chemical

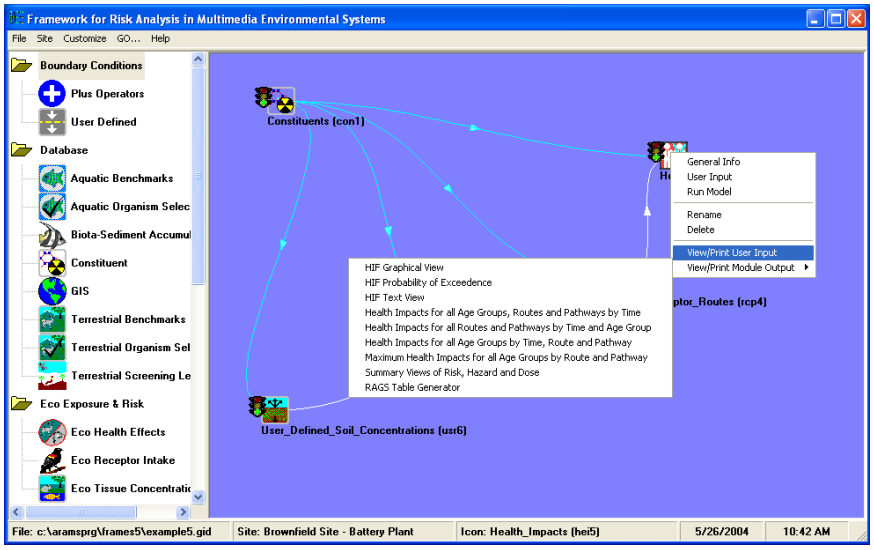

Figure 25. Health Impacts Output menu

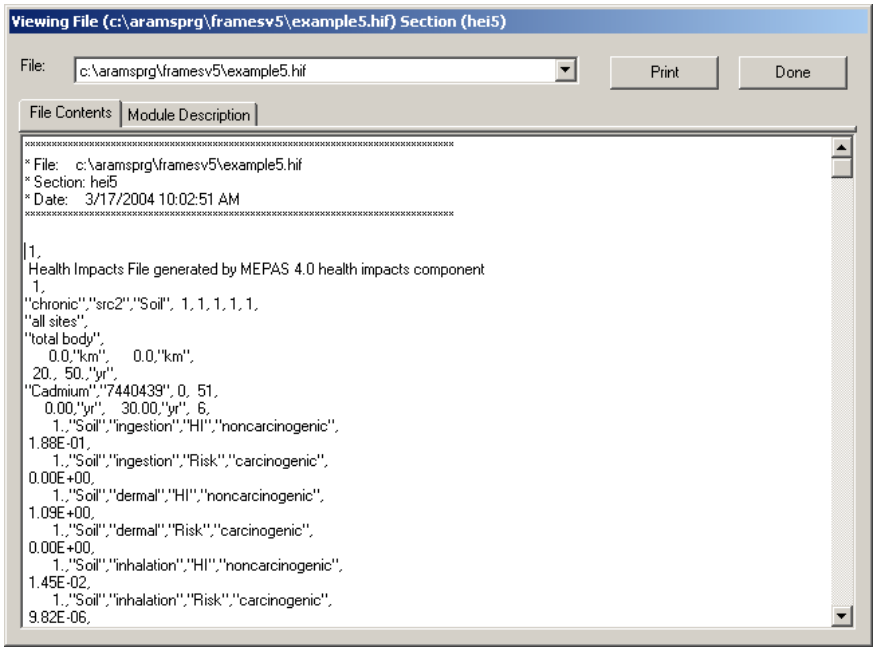

Figure 26. Health Impacts Output (text view)

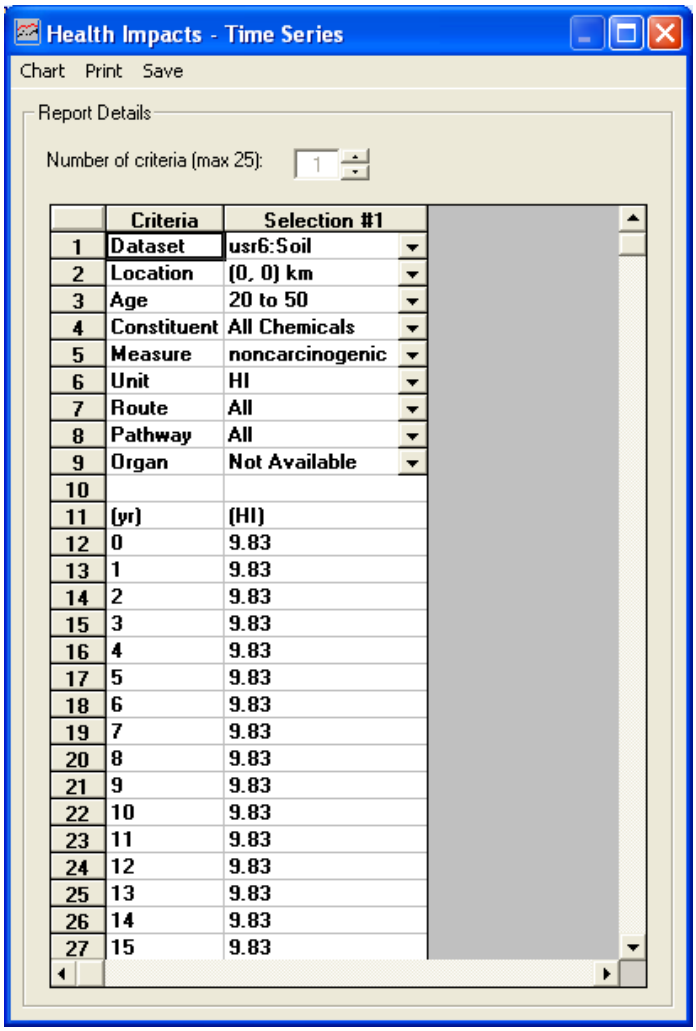

Figure 27. Health Impacts Output (graphical view)

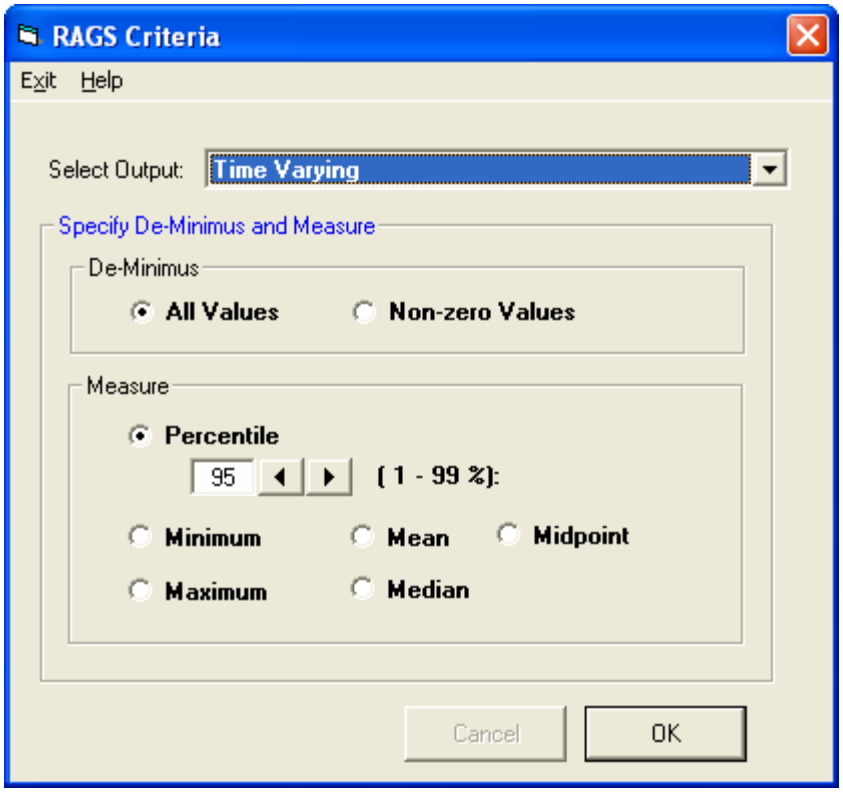

Figure 28. RAGS Generator Criteria Selection Interface

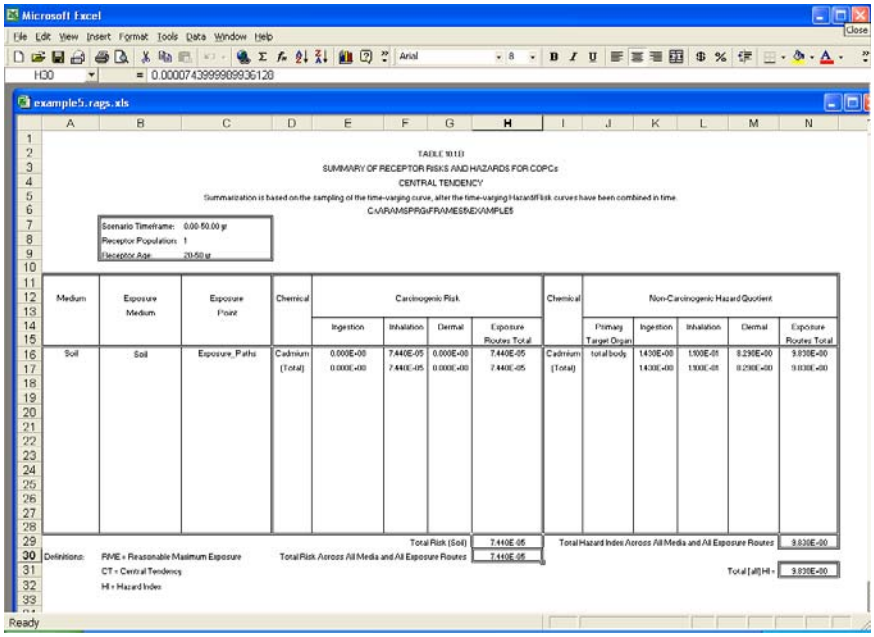

Figure 29. Example of RAGS Tables Generator Output

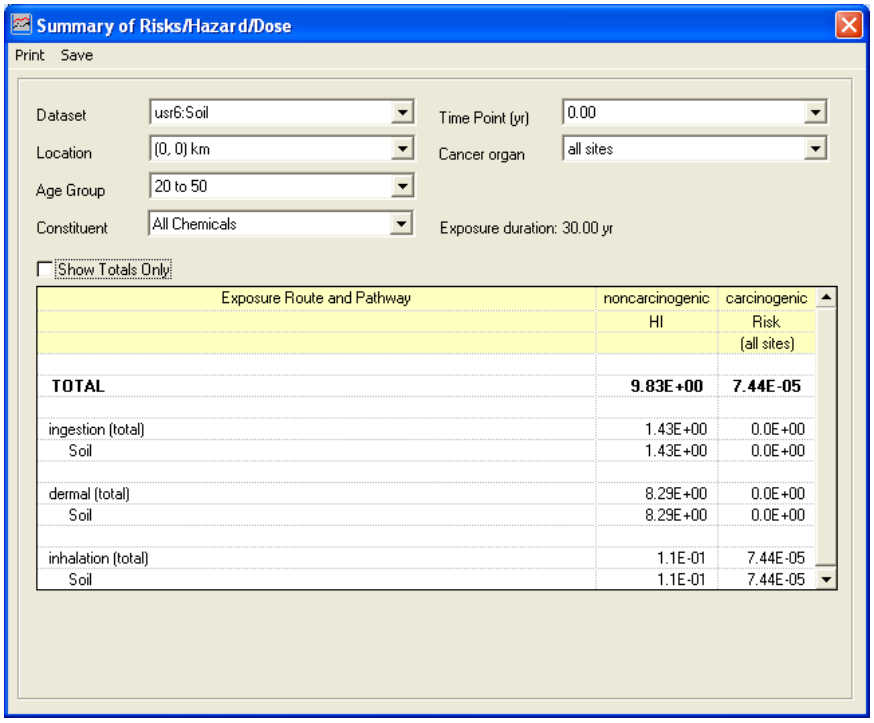

Figure 30. Summary of Risks/Hazard/Dose